Physics of Excited Nucleons (NSTAR 2013)
International Journal of Modern Physics: Conference Series
Vol. 26 (2014) 1460114 (5 pages)

DOI: 10.1142/S2010194514601148

QUASI-FREE PHOTOPRODUCTION OF η-MESONS OFF ^{2}H AND ^{3}He*

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Published 14 January 2014

In this work, we are presenting a combination of two preliminary results for quasi-free photoproduction of η-mesons from the liquid deuterium and ^{3}He targets for incident photon energies from threshold up to 1.4 GeV. The experiments were performed at the Mainz MAMI electron accelerator, using the Glasgow tagged photon facility. Decay photons of the η-mesons and the recoil nucleons were detected with an almost 4π covering electromagnetic calorimeter combining the Crystal Ball and TAPS detectors. The data from both targets show a narrow structure in the excitation function of $\gamma + n \rightarrow n + \eta$. The results from the two measurements are consistent within the expected effects from nuclear Fermi motion.

1. Motivation

Previous experiments within the GRAAL,[1,2] LNS-Sendai[3] and CBELSA/TAPS[4,5] collaborations have reported a narrow structure at $W \approx 1680$ MeV in the total cross section of quasi-free η-photoproduction off the neutron. This structure is not seen on the proton and its nature is up to now still unknown. As the width of the structure is close to the experimental resolution of the different experiments the true width should be unusually small compared to known resonances in this energy range. Therefore, the structure can hardly be described using a single well-known broad nucleon resonance. Theoretical explanations thus include interferences of resonances[6] or contributions from intermediate meson loops.[7] Another solution is provided by the chiral quark soliton model[8] which predicts an anti-decuplet nucleon resonance that couples strongly to the formation channel γn as well as to the final state ηN.

We report preliminary results from two different experiments performed at the tagged-photon beam facility at MAMI. In one experiment a liquid deuterium target was used as a neutron target, whereas in the other one a liquid ^{3}He target was installed.

2. Experimental Setup

The measurements were performed at the continuous wave accelerator facility MAMI[9,10] in Mainz. A schematic view of the experimental setup is shown in Fig. 1. A photon beam was produced from an electron beam of 1.5 GeV energy via bremsstrahlung using a copper radiator. The energy of the photons was determined by a momentum analysis of the scattered electron in a magnetic spectrometer (Glasgow photon tagger[11–13]). After collimation the beam impinged on the target (liquid deuterium or ^{3}He, respectively). The target was surrounded by a cylindrical plastic scintillator strip detector,[14] which was used for charged particle identification, and the spherical electromagnetic calorimeter Crystal Ball.[15] This detector consists of 672 NaI crystals and covers 94% of 4π steradians. The hole in the forward direction of the Crystal Ball was closed by the TAPS detector[16,17] which is made of 384 BaF_2 crystals (378 BaF_2 + 24 $PbWO_4$ crystals in the ^{3}He experiment). In front of every crystal a thin plastic scintillator element is installed as a charged particle veto detector. As trigger condition a deposited energy sum of 300 MeV in the Crystal Ball and a total multiplicity of two or more hits in both calorimeters was requested.

3. Data Analysis

Using the $\gamma\gamma$ and 6γ decay of the η-meson, the final state products of the quasi-free reactions γp$\rightarrow \eta$p and γn$\rightarrow \eta$n were selected by requesting 2(6) neutral clusters + 1 charged cluster or 3(7) neutral clusters, respectively, in the detector system. The η-mesons where identified in the invariant mass spectrum by applying a cut around

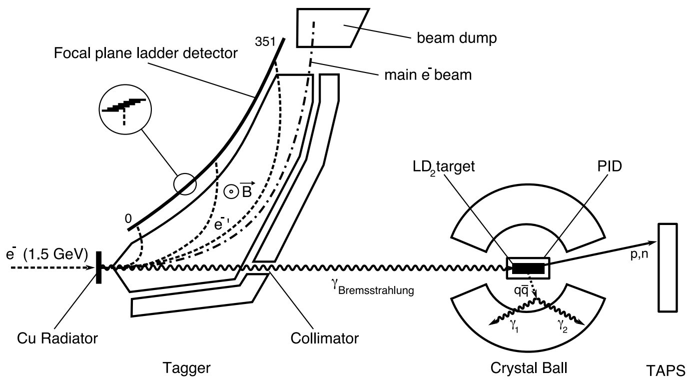

Fig. 1. Scheme of the experimental setup.

the η mass. Background coming from e.g. $\eta\pi$-photoproduction was suppressed by cutting on the ηN-coplanarity and the missing mass. The event selection criteria for both exclusive and inclusive channels are shown in the table below.

decay channel	σ_p $\gamma p \rightarrow \eta p$	σ_n $\gamma n \rightarrow \eta n$	$\sigma_{\mathbf{incl}}$ $\gamma N \rightarrow \eta N$
$\eta \rightarrow 2\gamma$	$2n_\eta$ & $1c_p$	$2n_\eta$+$1n_n$	$2n \mid \sigma_p \mid \sigma_n$
$\eta \rightarrow 6\gamma$	$6n_\eta$ & $1c_p$	$6n_\eta$+$1n_n$	$6n \mid \sigma_p \mid \sigma_n$

4. Preliminary Results

Preliminary results of the analysis are shown in Figs. 2 and 3. In the following, results for angular distributions are given in the *cm*-frame of the incident photon and the participant nucleon.

For the kinematically reconstructed results as a function of W, the *cm*-frame was derived event by event from the incident photon energy and the reconstructed nucleon momentum.

The previous results are confirmed for the ^{2}H measurement. Furthermore, the results of the ^{3}He are in good agreement with the ^{2}H measurement. An excess in

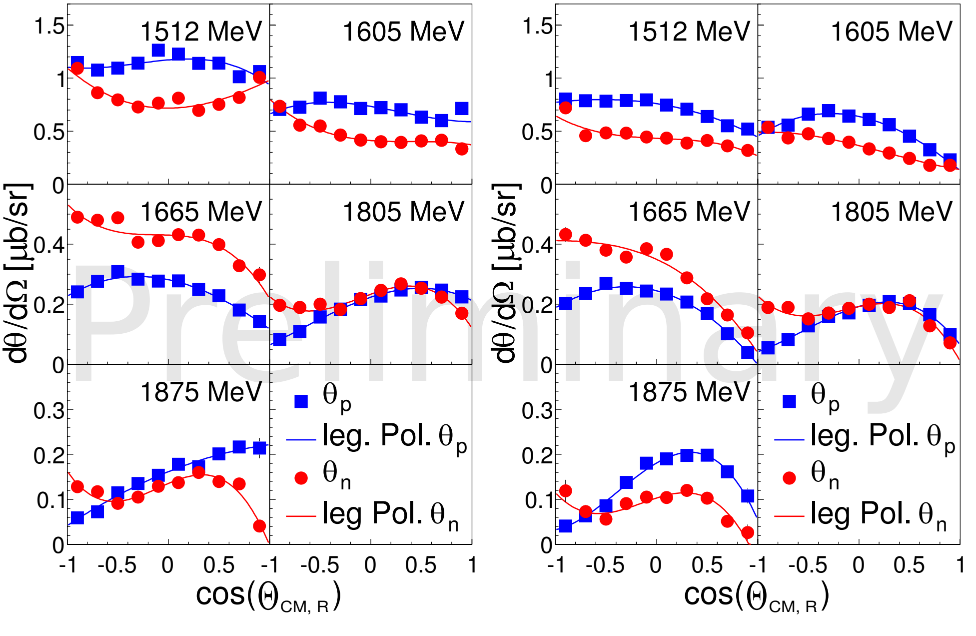

Fig. 2. Angular distributions (blue: proton, red: neutron) for different bins of incident photon energy. Left: ^{2}H and Right: ^{3}He. Solid lines: fits to data with Legendre polynomials. For the final results, all total cross sections will be extracted from integration of fit curves.

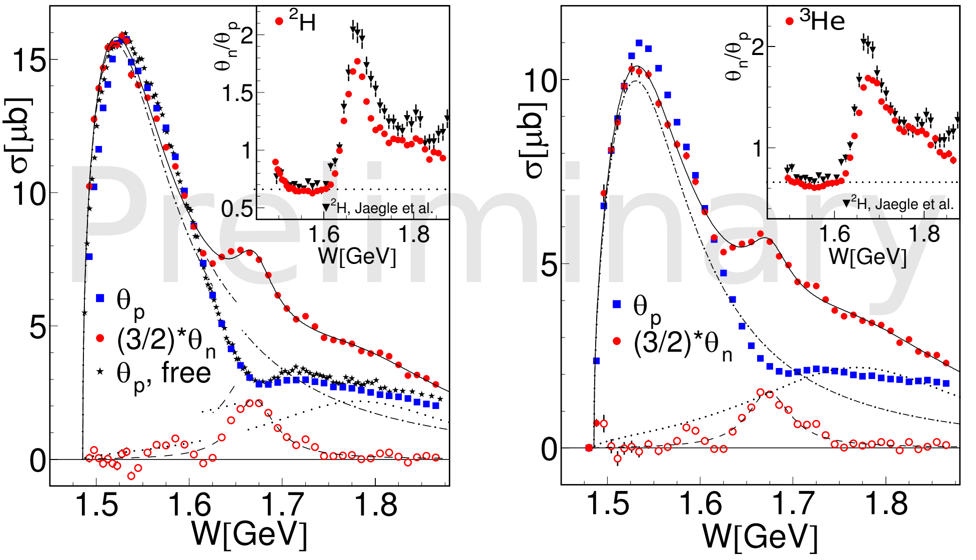

Fig. 3. Total cross sections as a function of reconstructed final-state invariant mass W. Left: ^{2}H and Right: ^{3}He. (Blue) squares: proton coincidence; (red) filled circles: neutron coincidence; (red) open circles: neutron excitation function after subtraction of S_{11} and background fit. Inserts at upper right corner, ratio of σ_p/σ_n for quasi-free η production. Both results are compared to previous published results from the CBELSA-TAPS collaboration.

the neutron cross section is observed which is not seen on the proton. The width of the structure in $\sigma(W_{rec})$, that is not affected by Fermi motion, is around 50 MeV and is mainly resolution dominated. The differences in $\sigma(W_{beam})$ seem to be only related to the larger Fermi motion inside the ^{3}He nucleus. Obtaining consistent results by using nuclei with different Fermi motion and σ_p/σ_n-ratio makes it very unlikely that the observed effect is caused by rescattering of mesons or FSI.

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